The Effect of Wood Sawdust Mesh Combination on Mechanical Behaviour of Particle Board

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Abstract. Particle boards are widely used as furniture materials in the world. The particle boards on the market have a disadvantage that is when this materials contact with water, the mechanical properties decrease significantly. Material engineering is carried out by changing the particle board composition and other factors. One of the factors that influence the quality of particle board is wood sawdust mesh. Filler mesh combinations are carried out to obtain the best quality particle board. The result of experiment refers to SNI 03-2105-2006 for some mechanical properties, such as density, thickness swelling, hardness, bending strength, and impact toughness. The compositions of particle board in this research are 15% fibre of oil palm, 50% wood sawdust, 15% resin epoxy and 20% polyvinyl acetate (PVAc). Samples were carried out by cold press single punch method with pressure 30 bar. The result from this research known that the best mechanical properties of particle board on filler mesh combination M40-60-80, those are: density 0.95 g/cm^3, thickness swelling 1.93%, hardness 29.30 N/mm^2, bending strength 16.38 MPa, and impact toughness 3.38 kJ/m^2. This value has exceeded the particle board on the market.

Keywords: wood sawdust, mesh combination, particle board, mechanical behavior

1. Introduction

Nowadays, demand of wood as household material continues to increase, in contrast wood production actually decreases. To anticipate this condition, alternative materials are needed as a substitute for natural wood. The alternative materials are particle boards made by the varieties of wood waste. The particle board on the market will be damaged when there is a direct contact between the particle board and a water. This condition will cause the bond strength between the matrix and fibres become decrease. Therefore, the particle board will lose its function as furniture material.

Lebak and Pandeglang district are producers of palm oil in Banten, Indonesia. These productions reach of oil palm 25.249 tons/year. The high production capacity of palm oil certain is accompanied by environmental problem, such as palm oil waste. Palm oil waste can be used as a constituent of particle board. The waste used in this study is oil palm empty bunches fiber as composite reinforcing material. As we know, the particle board will be decreased if it has a direct contact with the water.

This study discusses the combination of wood sawdust mesh to obtain the better particle board properties.

Various researches have been studied about potency of palm oil waste for particle board [1]–[3]. The effect of oil palm empty bunches fibre as particle board reinforcement has been studied. In this research, volume fraction of 5%, 10% and 15% was used. From this research, it is known that the 15% fibre volume fraction has the best mechanical properties as particle board [4]. Coal fly ash and bamboo powder have been studied as alternative materials for brake disc. The higher composition of fly ash increase the hardness and density, but the porosity and wear rate decrease [5].

The size of wood filler affects the quality of particle board. Filler used in this research is "sengon" wood (albizia chinensis) which has 18, 40, 60 and 80 mesh respectively. From this research, it is known that particle board with mesh 18 has better performance as stipulated in SNI 03-2105-2006 [6]. The mechanical properties of composites were found to be a function of particle size, aspect ratio, the dispersion, and the particle orientation. Spherical shaped filler gave significant improvement in stiffness due to better surface area for interaction. Fly ash with smaller particle size can improve its mechanical and electrical properties [7]. Type and size of filler affect the polymer composite behaviour.

The effect of filler size on tensile strength, elongation and absorbed energy has been studied. Wood sawdust filler with size 0.4-1 mm have the best characteristics compared with smaller or larger filler. From this research is also known that particles with longer elongated shape have better resistance when compared with spherical or rectangular particles [8]. The grain size behavior of periwinkle shell as filler in making natural composite is known that the higher filler size decreases the density, tensile strength, elastic modulus, impact strength and hardness. The filler sizes used in this research were 75, 125 and 150 μm [9].

The combination of albizia chinensis wood sawdust mesh as filler will affect the mechanical properties of particle board. The characteristic of particle board with mesh combination will be discussed further in this paper.

2. Methodology

2.1. Material

As reinforce for particle board, we used empty palm oil bunches fibres from Banten, Indonesia. Before use this fibre, it is immersed in a 5% NaOH solution for 2 hours. Filler used in this research is albizia chinensis wood sawdust. The other material is epoxy resin and PVAc for matrix.

2.2. Sample Preparation

Particle board samples consist of 15% palm oil bunch fibres with a length of 15 mm, 50% wood sawdust, 20% PVAc and 15% epoxy resin. Samples were made by hydraulic press machine at 30 bar pressure. Shape of particle board specimens are beam with a length of 150 mm, width of 100 mm, and height of 40 mm. The combination of filler used 3 different meshes, namely: M18-40-60, M18-40-80, M18-60-80 and M40-60-80. Mechanical properties obtained in this study are density, thickness swelling, hardness, flexural strength, and impact strength.

2.3. Mechanical Testing

Bending tests refer to ASTM D790-10, Charpy impact testing (ISO 179-2010), and hardness (ISO 2039-1-2010). Environmental conditions and test parameters refer to each of these standards.

3. Result and Discussion

3.1. Density

The combination of filler mesh greatly affects the density of particle board. According to SNI 03-2105-2006 standard that particle board density is between 0.40 - 0.90 gr/cm^3. If it refers to this SNI standard, only the combination of filler mesh M18-40-60 fulfills it.

The higher filler mesh combination, the particle board density also increases. This is due to contact filler surfaces with matrices able to reinforce particle board bonding. So, the ability of particle board to withstand deformation is higher. The existing particle board density today is 0.660 gr/cm^3. It shows that the particle board density in this research is better than that on the market. The right combination of filler meshes can improve the mechanical properties of particle board, especially its hardness.

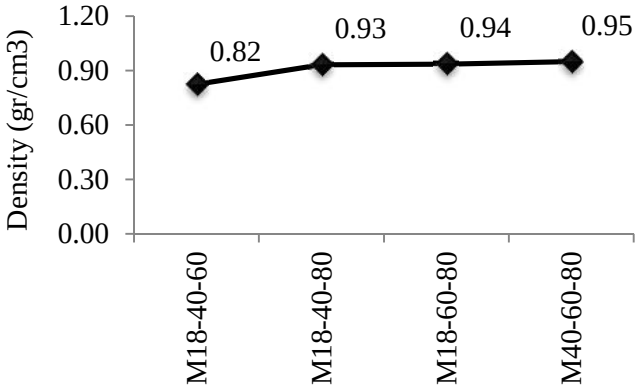

Figure 1. The effect of the filler meshes combination on particle board density

3.2. Percentage of swelling thickness

Thickness swelling is the main problem of particle board. The existing particle board on the market undergoes degradation of mechanical properties drastically when it contact with water. This condition reduces the function of particle board as a furniture material. The combination of the filler meshes affected the thickness swelling as shown in Figure 2.

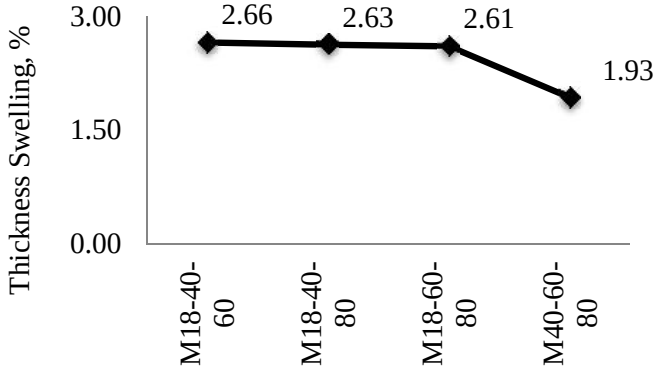

Figure 2. The effect of the filler mesh combination on the thickness swelling of the particle board

Figure 2 shows the correlation between the filler mesh combination and the percentage of thickness swelling of the particle board. The thickness swelling is inversely proportional toward its density. The combination of a sequential filler mesh can provide the most optimal thickness swelling. When compared to the density value, the density value decreases linearly to the thickness development. The correlation between the density and the thickness development of the particle board can be expressed in a graph like Figure 3 below.

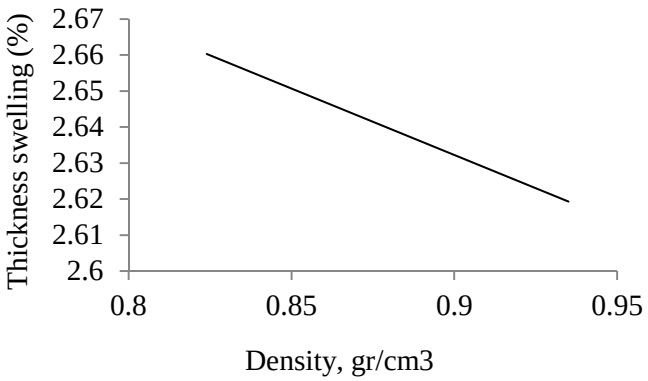

Figure 3. Correlation between density and thickness swelling of particle board

3.3. Hardness

Particle board hardness is a very important mechanical property when the material undergoes friction or impact in application. The particle board hardness can be showed in Figure 4. From Figure 4 is known that the highest hardness of particle board occurs on the combination of M40-60-80. The combination of filler mesh in sequence has the highest hardness. This phenomenon can be seen on M40-60-80 and is followed by M18-40-60. This indicates that the contact bond between matrix and filler surfaces occurs well.

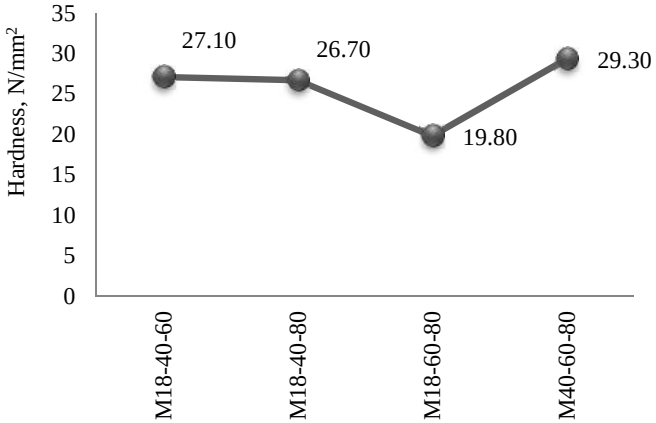

Figure 4. The effect of the filler mesh combination on particle board hardness

3.4. Bending strength

In its application, the particle board will be subjected to flexible loading. For this reason, bending testing becomes important to be done. In any applications, the loading can be very dominant when the used beams have the stretch.

Although not significant, filler mesh combinations affected to mechanical properties of particle board. This condition can be shown by Figure 5. The combination of fillers that have large mesh tends to be better. The surface contact between the filler and the matrix is the cause of the strong bond in composite. Of course, this condition has an impact on particle board resistance to its hardness and flexibility.

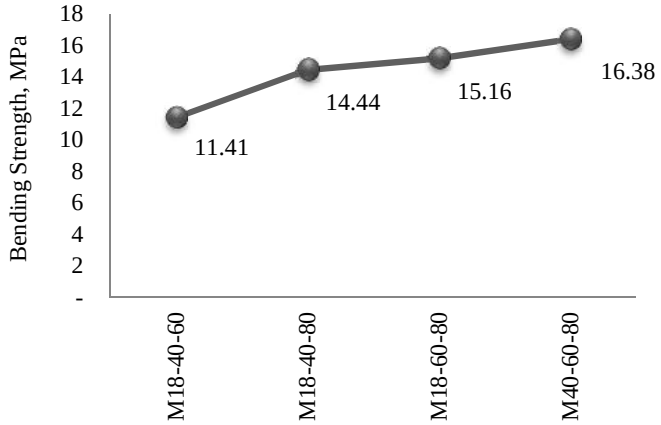

Figure 5. The effect of the filler mesh combination on the bending strength

According to SNI 03-2105-2006, the minimum bending strength of particle board is 8.20 MPa. Referring to this standard, the particle board in this research has already exceeded its bending strength of existing particle board on the market.

3.5. Impact strength

The combination of filler mesh can affect the mechanical properties thoroughly. The right combinations can improve certain properties, but decrease in other characteristics. An interesting phenomenon is the low impact strength on the M40-60-80 combination, whereas in other properties, M40-60-80 has the most optimal properties.

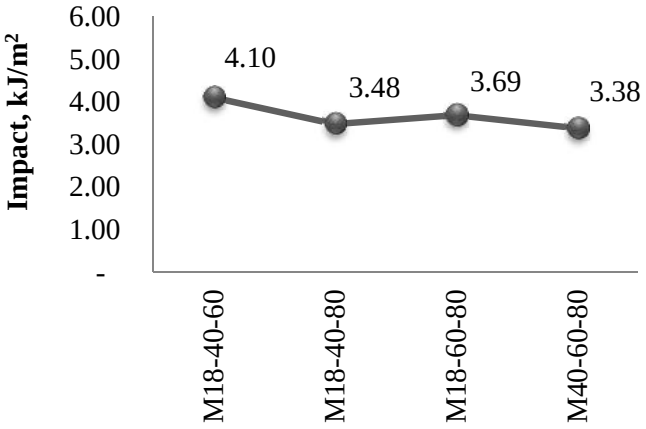

Figure 6. The effect of the filler mesh combination on impact strength

4. Conclusion

From the description above, it can be concluded as follows:

1. The combination of filler meshes have an influence on the mechanical properties of particle board.
2. The particle board has the optimum result is combination of M40-60-80 with the following values: density 0.949 gr/cm^3, percentage of thickness swelling 1.93%, hardness 29.30 N/mm^2, flexural modulus 1.402 GPa, bending strength 16.38 MPa and its impact strength is 3.38 kJ/m^2.

Acknowledgments
This research was funded by the Ministry of Research, Technology and Higher Education of the Republic of Indonesia. We would like to thank you, Direktorat Riset dan Pengabdian kepada Masyarakat Ditjen Penguatan Riset dan Pengembangan, Lembaga Penelitian dan Pengadian kepada Masyarakat Universitas Sultan Ageng Tirtayasa, Metallurgical Engineering Laboratory and LIPI Serpong who helped this research.

References
[1] R. Lusiani, Sunardi, and Y. Ardiansyah, "Pemanfaatan Limbah Tandan Kosong Kelapa Sawit Sebagai Papan Komposit dengan Variasi Panjang Serat," in *Seminar Nasional Integrasi Proses*, 2014, pp. 240–248.
[2] R. Senawi, S. M. Alauddin, R. M. Saleh, and M. I. Shueb, "Polylactic Acid / Empty Fruit Bunch Fibre Biocomposite : Influence of Alkaline and Silane Treatment on the Mechanical Properties," vol. 3, no. 1, pp. 1–3, 2013.
[3] C. M. Ewulonu and I. O. Igwe, "Properties of Oil Palm Empty Fruit Bunch Fibre Filled High Density Polyethylene," vol. 3, no. 6, pp. 458–471, 2012.
[4] M. C. Sunardi, Moh. Fawaid, "Pemanfaatan Serat Tandan Kosong Kelapa Sawit Sebagai Penguat Papan Partikel Dengan Variasi Fraksi Volume Serat," *Mach. J. Tek. Mesin*, vol. 2, no. 1, pp. 36–39, 2016.
[5] Sunardi, M. Fawaid, and F. R. N. M, "Variasi Campuran Fly Ash Batubara Untuk Material Komposit," *Flywhele J. Tek. Mesin Untirta*, vol. I, no. April, pp. 90–102, 2015.
[6] Sunardi, R. Lusiani, and R. Parulian, "Pengaruh Butiran Filler Kayu Sengon Terhadap Karakteristik Papan Partikel Yang Berpenguat Serat Tandan Kosong Kelapa Sawit," *J. Mesin Teknol. (SINTEK Jurnal)*, vol. 11, no. 1, pp. 28–32, 2017.
[7] V. R. Gaval and R. S. N. Sahai, "Effect of Particle Size and Concentration of Fly Ash on Properties of Polytrimethylene Terepthalate," in *International Conference on Chemical, Mettallurgy and Material Science Engineering (CMMSE 2015)*, 2015, pp. 46–51.
[8] O. M. Terciu, I. Curtu, and H. Theodorescu-Draghicescu, "Effect of Wood Particle Size on Tensile Strength in Case of Polymeric Composite," in *8th International DAAAM Baltic Conference*, 2012, no. April.
[9] S. C. Nwanonenyi, M. U. Obidiegwu, and G. C. Onuegbu, "Effects of Particle Sizes , Filler Contents and Compatibilization On The Properties Of Linear Low Density Polyethylene Filled Periwinkle Shell Powder," *Int. J. Eng. Sci.*, vol. 2, no. 2, pp. 1–8, 2013.